

# Efficiency of Output Power in Ring Cavity of Erbium Doped Fiber Laser

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**Abstract** -The output power and efficiency of erbium doped fibre laser (EDFL) based on ring configuration have been proposed and presented. Erbium doped fibre laser is demanded in fibre laser technology as it features 1.5 micron wavelength region which has attracted much interest due its potential in many applications such as optical communication and optical sensor application. Therefore, an optical hands-on rare earth doped fibre laser experiment made in ring cavity has been proposed and experimentally demonstrated. This experiment is achieved by utilizing erbium ( $\text{Er}^{3+}$ ) doped fibre as its gain medium in the cavity. The fibre ring cavity laser consist of EDFL, 980 nm pumping source laser diode, wavelength division multiplexing (WDM), output coupler, OSA, and optical power meter. The results for optical spectrum laser threshold and efficiency of EDFL ring cavity are analysed.

**Keywords:** *Output power, erbium doped fibre, fibre laser, gain medium, efficiency.*

## 1. INTRODUCTION

In recent years, fibre laser has face tremendous focus among researchers in the field of laser as it plays crucial roles in wide range of applications in the area of optical communication, optical sensing, materials technology, life sciences and precision mechanics, national defence science and other areas [1]. The fibre laser itself is simple, has compact construction and lower in cost compared to conventional laser [2]. In the industrial and manufacturing sector, fibre laser has a flexibility in light guiding and delivery which allowing it to be consumed in industrial robots [3]. Apart from that, the Aerospace sector also utilizing fibre laser due to its inherent lightweight, robustness and low maintenance [3].

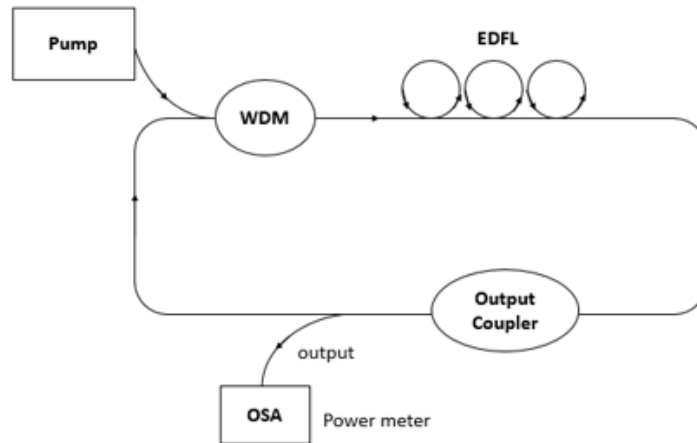
A fibre laser is a laser in which the optical fibre act as medium to transmit signals in the form of laser light. The active medium of fibre laser is doped with rare-earth elements for example erbium, ytterbium, neodymium, dysprosium, praseodymium and thulium [1] in which each of them has their corresponding output wavelength emitted. After the discovery of lasing phenomenon of the first ruby laser by Maiman in 1960, fibre lasers then were potentially identified and demonstrated at the late eighteenth [4]. Next after that, a vast number of research have been done in the field of fibre laser because it is practical and could be demonstrated in the laboratory.

In this paper, a clear hands-on experimental structure of erbium doped fibre laser is demonstrated in ring configuration. Special attention is placed on the study of its efficiency by characterising the output power where it is analysed on OSA.

## 2. EXPERIMENTAL

The basic configuration of fibre laser is shown in Fig.1. In this experimental setup, EDFL is specifically being performed in a ring configuration or cavity. A fixed laser outputting 1550 nm beam is used as the signal laser and a fixed 980 nm laser diode is used as a pump. The pump and signal beam are combined using a wavelength division multiplexer (WDM) and the output is sent through a length of optical fibre doped with  $\text{Er}^{3+}$ . The amplified light are then passed through an output coupler and then the optical spectrum analyser

(OSA) will measure the output power in units of dBm. The analysis of EDFL begins with calibrating the pump laser used. Table 1 shows the calibration of the output power of laser diode pump and output power of EDFL as a function of current of laser diode 980 nm for ring configuration. The input current given are from 0 mA to maximum 500 mA, however in this paper only the readings which there is lasing action are tabulated.



**Figure 1.** Schematic diagram of EDFL experimental setup.

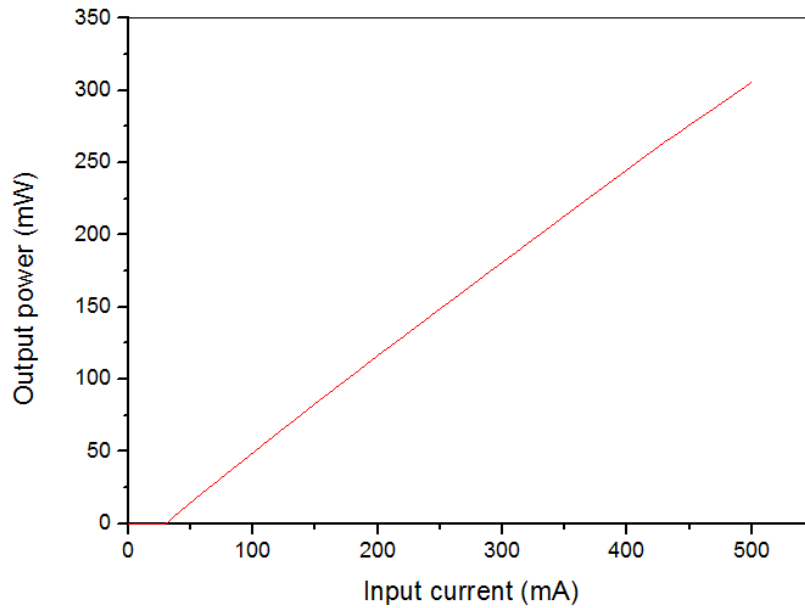
**Table 1.** The output power of laser diode pump and output power of EDFL as a function of current of laser diode 980 nm for ring configuration.

Input current from laser diode 980 nm (mA)	Output power of laser diode 980 nm (mW)	Output power of Erbium doped fiber laser (mW)
290	168.0	0.10
300	129.0	0.11
350	153.4	0.17
400	177.8	0.22
450	202.2	0.28
500	226.1	0.36

### 3. RESULT AND DISCUSSION

#### 3.1 Output power characterisation of 980 nm laser diode pump

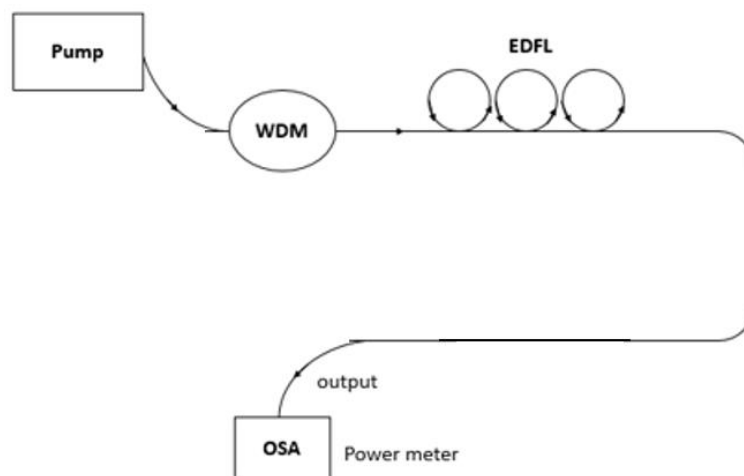
A 980 nm laser diode is used throughout the experiment as the pumping source for the Erbium doped fibre to generate laser at the range of 1550 nm in ring cavity. Fig. 2 shows calibration graph of output power (mW) laser diode as a function of given input current (mA). It is important to calibrate the laser diode for example how much maximum output power it produces when maximum input current is increased to 500 mA. The calibration data then became the reference readings for laser threshold characterization.



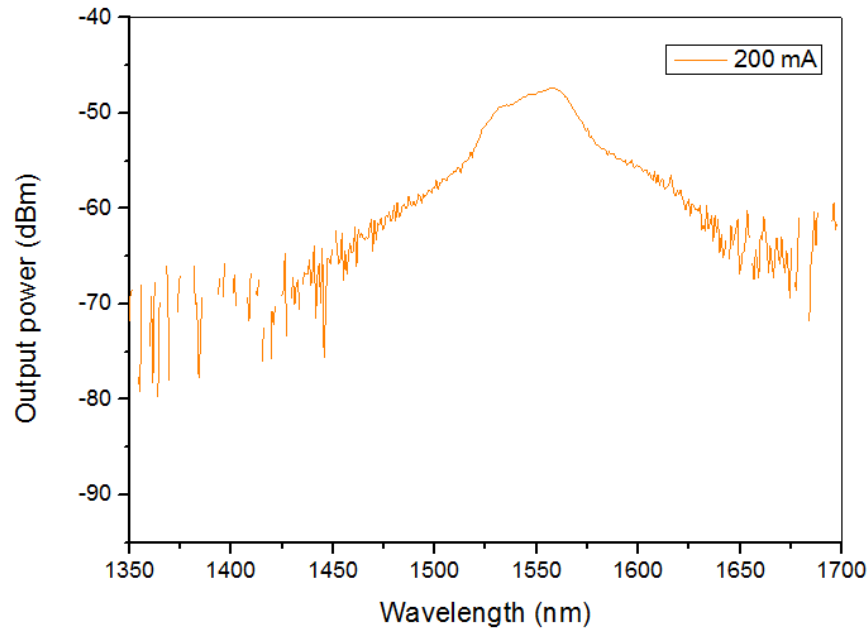
**Figure 2.** The graph of calibration of 980 nm laser diode pump.

### 3.2 ASE characterization

ASE is present in EDF where the output coupler is not included as shown in Fig 3. Once it is included, the ring cavity is completed and EDF could lase. The amplified signal passes along the fibre and is considered as the output signal of Erbium-doped fibre laser which is analysed by the OSA.



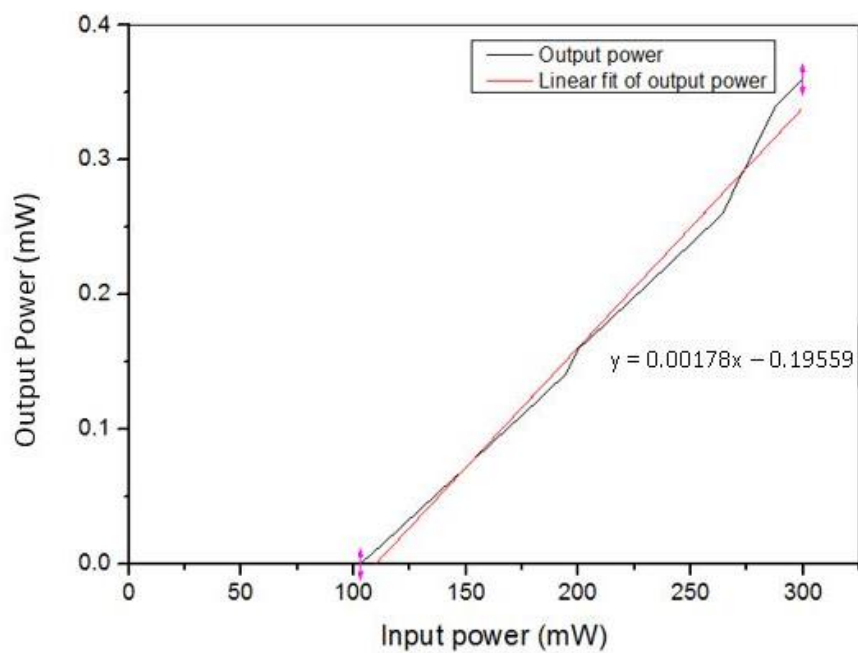
**Figure 3.** Schematic diagram of ASE experimental setup without output coupler.



**Figure 4.** The optical spectrum of 1550 nm ASE light source.

### 3.3 Laser threshold characterization

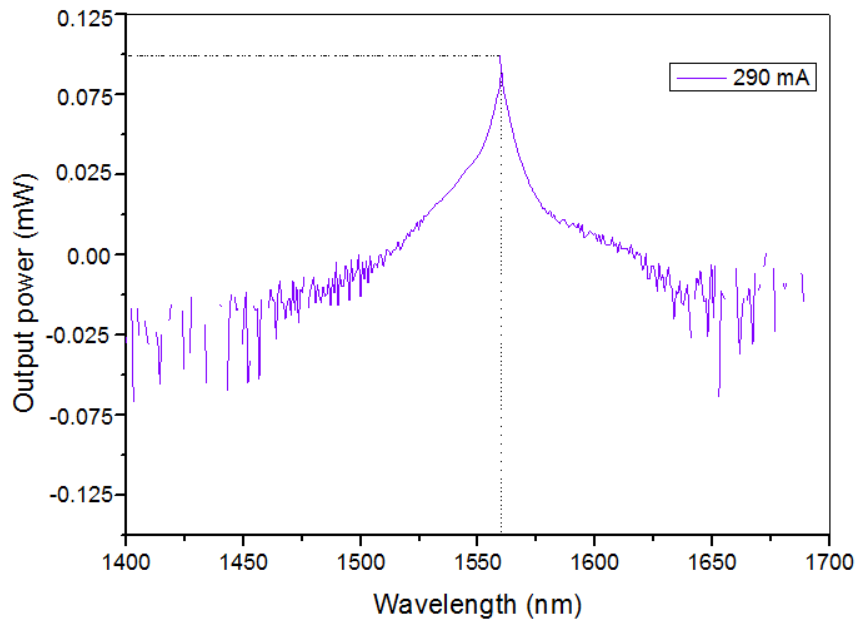
Laser threshold is a condition at which light amplification becomes possible in a laser that finally causes lasing at the minimum input power given. Lasing occurs when gain exceeds optical loss during one trip through the cavity. The EDF start to lase at 0.1 mW when input current of 290 nm is given where the output power from laser diode is 168 mW. This spectrum is clearly shown in Fig 6.



**Figure 5.** Laser threshold and the slope efficiency.

The efficiency of EDFL is given by the equation below which is obtained from the slope of laser threshold graph in Fig. 5.

$$\text{Slope efficiency} = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\% \quad (1)$$



**Figure 6.** The peak of lasing spectrum of EDFL at 290 mA.

#### 4. CONCLUSIONS

The efficiency of EDFL could be determined from the slope efficiency of the graph output power EDFL against input power of pump laser where for this experiment it measured as 0.178%. The ASE spectrum were observed. The output power is at 0.1 mW where lasing occur.

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